Institute for Environmental Studies

(NASA-CR-137397) A MULTIDISCIPLINARY RESEARCH PROGRAM ON THE ENVIRONMENT Final Report (Mississippi State Univ.) 12 p

N74-72461

Unclas
00/39 16049

FINAL REPORT

NASA Grant NGL-25-001-028

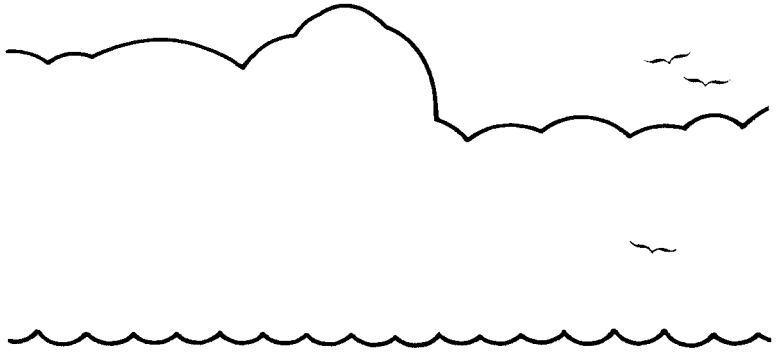
"A MULTIDISCIPLINARY RESEARCH PROGRAM ON THE ENVIRONMENT"

C. W. Bouchillon
Principal Investigator

June 30, 1973

Submitted To:

NASA - Headquarters
Office of University Affairs
Code PY
Washington, D.C. 20546



Mississippi State University

Final Summary Report

A MULTIDISCIPLINARY RESEARCH PROGRAM ON THE ENVIRONMENT

I. ABSTRACT

This summary report constitutues a brief assimilation of information pertinent to the program of research conducted under the support provided by this grant from NASA--($300,000)--and the matching funds from Mississippi State University--($15,000). Details concerning the title of the research projects, statistical information relative to these projects, brief descriptions of the projects and resultant publications are presented below.

Detailed technical reports of research findings conducted during the report period in these projects have previously been submitted or published elsewhere and will not be repeated herein. The projects "Particle Dynamics Research Associated with Rocket Exhaust Clouds," "Atmospheric Environmental Perturbations Resulting from Gravity Waves," and "Establishment of an Environmental Science Laboratory at MTF," were supported both by the subject grant as well as NASA-NGL-25-001-032. Because of the importance of these two projects additional funding was provided jointly from both grants.

Advantages accruing to the University as a consequence of the availability of the funds for the conduct of this program served to:

(1) Establish the philosophy and mechanisms for excuting multidisciplinary/interdisciplinary research programs at Mississippi State University,

(2) Established a strong interaction with the NASA-Mississippi Test Facility with special emphasis on environmental programs,

(3) Provided support funds for faculty and graduate students to perform meaningful research,

(4) Provided travel funds for the establishment of better interactions with NASA centers and other government agencies in programs related to environmental problems,

(5) Provided the basis for the establishment of an environmental science laboratory at the Mississippi Test Facility,

(6) Provided experience in multidisciplinary/interdisciplinary research programs which resulted in substantial participation in other programs, for example, a Mississippi Sea Grant Consortium has been formed subsequent to the initiation of this grant and significant programs are currently in progress; the Gulf Universities Research Consortium is a multi-university supported interdisciplinary/multidisciplinary research organization sponsored by Mississippi State University, 18 other gulf state universities and some 10 industrial companies for marine related research activities; and other research program support obtained solely at Mississippi State University for interdisciplinary activities in environmental, ecological, and remote sensing application programs, and

(7) Additional advantages are discussed in the discrete project descriptions below.

The total program advantages accruing to the university extend far beyond the individual research findings reported herein and has made significant contributions toward the enhancements of the capabilities of Mississippi State University.

Sincere appreciation is hereby expressed to the National Aeronautics

and Space Administration for the funding provided to allow the activities undertaken in this program.

II. LIST OF RESEARCH PROJECTS

A. "A Multidisciplinary Research Program on the Environment"

C. W. Bouchillon - Principal Investigator
$132,000.00 Total

B. "Particle Dynamics Research Associated with Rocket Exhaust Clouds"

M. R. Smith - Principal Investigator
R. E. Forbes - Co-Principal Investigator
$28,000.00 Total

C. "Atmosphere Environmental Perturbations Resulting from Gravity Waves and Magnetohydrodynamic Waves"

D. L. Murphree - Principal Investigator
$25,000.00 Total

D. "Establishment of an Environmental Science Laboratory at the Mississippi Test Facility"

L. R. Brown - Principal Investigator
$130,000.00 Total

The Total Funding of all the above projects was $315,000.00.

NASA - $300,000.00

MSU - $ 15,000.00

III. STATISTICAL INFORMATION

A. Number of faculty supported under this grant - 10

B. Number of students who received support under this grant - 14

C. Number of Departments involved in this grant - 7

D. Number of students supported who received doctoral degrees - 2

E. Number of students supported who received master's degrees - 6

F. Number of papers resulting from this support - 12

IV. SUMMARY OF RESEARCH PROGRAMS

A. A Multisciplinary Research Program on the Environment

The first year's effort was aimed at developing a capability for the performance of interdisciplinary research relating to the environment. The disciplines of electrical engineering, aerophysics and aerospace engineering, mechanical engineering, physics, microbiology, economics, and sociology were represented. Many meetings were held in which the programmatic approach to research in the subject area were held. The support base for the program with this wide diversity of interest was unmatched to the problems under consideration. As a consequence, with the basis of support through other sources, it was deemed advisable to subdivide the efforts into more closely related subdivisions of activities.

Five general areas were pursued. These were: ecology, environmental systems, environmental sciences, earth resources, and socio-economics-science and technology.

Several projects and programs have evolved in each of these areas as a consequence of these early study activities.

Efforts in ecological studies were supported and more discussion is given below concerning the development of programs in this area.

In the area of environmental science which embraces meterology, oceanography and earth sciences, efforts have been made to develop programs in this area, however, because of a limited educational and research base at the University, little has been done in this direction. Some programs are currently underway through the Mississippi Gulf Coast Research Laboratory in physical oceanography.

Environmental systems embraces those activities which interface man's activities with the natural environment. Several projects have been

developed by the university outside of the group involved in the NASA grant in this area.

Earth resources applications have been pursued successfully in an interdisciplinary program activity. The first of these involved a multi-university activity to delineate the needs for remote sensing data for state and regional areas in Mississippi. This research was conducted by Mississippi State University with the University of Southern Mississippi and the Gulf Coast Research Laboratory as subcontractors. Two ERTS contracts and one Skylab-EREP contract have also resulted in this area. The use of infrared photography for an environmental impact study of the Tennessee-Tombigbee Waterway for the Corps of Engineers was also undertaken. A state-supported project in the Department of Forestry is also underway.

In socio-economics - science and technology, the primary indirect resulting activity has been in the Sea Grant Program in developing a coastal leaders conference with a view of identification and proposed resolution of coastal problems. Experience with the interdisciplinary aspects of the initial NASA program helped to further the activities involved in the Sea Grant program.

B. NASA Particle Dynamics Task

The purpose of this project was to study, both experimentally and analytically, atmospheric diffusion of combustion products generated during the static firing of large rocket engines. The work was performed both at Mississippi State University and on site at NASA Mississippi Test Facility (MTF). The experimental phase consisted of instrumenting a light aircraft and flying it through the clouds to map the thermal and moisture content of the clouds. Additionally, the transient geometry of the clouds

was determined from time lapse photography using ground based cameras. The analytical portion of the work consisted of computer simulation of the diffusion process.

The experimental phase of the study, conducted at MTF during the static firing of the S-IC-13, -14, and -15 rocket engines, was directed toward the acquisition of data. These included photographic recordings of the time-dependent growth and diffusion of the exhaust clouds, the collection of meteorological data in the ambient atmosphere, and data on the physical structure of the exhause clouds. The latter was obtained by flying instrumented aircraft through the clouds.

Verification of previous measurements of evaporation and entrainment of blast deflector cooling water was by the technique of injecting small (ca. 10 micron diameter) hollow glass beads into the cooling water at the pumping station. These particles were detected subsequently, using an impact-type sampler, on all passes through the clouds. The beads are clearly identifiable under a microscope, and are sufficiently small that they may be injected into natural clouds at the updrafts near the base of the clouds.

The results of this phase indicate that, at the lower altitudes, the rocket exhaust stream or plume closely resembles a free-jet type of flow. At the upper altitudes, where the cloud is approaching an equilibrium condition, the structure is very similar to a natural cumulus cloud.

The analytical phase was directed toward developing a direct numerical method for predicting concentration profiles in a turbulent boundary layer over a flat plate. A numerical solution to the turbulent mass transport equation utilizing the concept of eddy diffusion was presented as an efficient method of investigating turbulent mass transport in boundary layer type flows. A Fortran computer program was used to study the two-dimensional diffusion of ammonia, from a line source on the surface, into

a turbulent boundary layer over a flat plate. The results of the numerical solution were compared with experimental data to verify results. This computer program was utilized on several other diffusion problems both to demonstrate the versatility of the program and to provide some insight into the overall problem of mass diffusion.

1. Advantages to University from this Project:

a. Work was performed jointly with NASA MTF personnel and MSU personnel using facilities on campus at MSU and on site at MTF.

b. Development of expertise in area of micro-meterology thus allowing university personnel to bid on research in this area.

c. Support of faculty, graduate, and undergraduate students during period of research.

d. Development of computer programs to predict concentration profiles for a diffusing pollutant.

e. Development of computer plotting routines compatible with plotting equipment available at NASA MTF.

2. Papers

a. Smith, Michael R., and Johnson, Richard A., "Airborne Data Acquisition System for Atmospheric and Meteorological Research" Presented at the Seventeenth International ISA Aerospace Instrumentation Symposium, May 10-12, 1971, Las Vegas, Nevada; reprinted from the proceedings entitled, "Instrumentation in the Aerospace Industry - Volume 17" -- Instrument Society of America, Pittsburgh, Pennsylvania.

b. Forbes, R. E., "The Geometry and Physical Properties of Exhaust Clouds Generated During the Static Firing of Large Rocket Engines", Flow Studies in Air and Water Pollution, ASME, June 1973.

c. Smith, Michael R., Forbes, R. E., and Farrell, Ralph, "The Geometry and Physical Properties of Exhaust Clouds Generated During the Static Firing of S-IC and S-II Rocket Engines - NASA CR-2049.

d. Dow, James W., "A Director Numerical Method for Predicting Concentration Profiles in a Turbulent Boundary Layer Over a Flat Plate" - NASA CR-2050.

3. Thesis

Dow, James W., "A Direct Numerical Method for Predicting Concentration Profiles in a Turbulent Boundary Layer Over a Flat Plate", M.S., January 1972.

C. Atmosphere Environmental Perturbations Resulting from Gravity Waves and Magnetohydrodynamic Waves

Our knowledge of the ionosphere and its interactions with the neutral atmosphere has increased rapidly in the past decade due to the availability of a greater wealth of better observational data combined with the capability of advanced computer systems to handle complicated numerical problems.

Complex theoretical models and their numerical solutions on large computer systems are a requisite to the further advancement of our knowledge. Theoretical models of wave propagation in a three-fluid plasma were developed and numerical solutions to certain aspects of the dispersion and propagation characteristics were obtained. Use of the PL/1-FORMAC Mathematical Interpretator in the IBM-360-40 computer was employed. The complexity of modelling a three-fluid plasma was presented in a series of papers describing theoretical modelling and numerical solutions.

The Magnetoplasmadynamic Laboratory at Mississippi State University was further developed with the resulting improvements providing us with a plasma laboratory in which we can conduct state-of-the-art plasma research.

Publications -

"Numerical Solution for Propagation of Longitudinal Waves Along the Applied Magnetic Field in a Three-Fluid Partially Ionized Gas," T. L. Dahl and D. L. Murphree, Research Report AASE-70-27, Department of Aerophysics and Aerospace Engineering, MSU, August 1970.

"Numerical Solution for Propagation of Coupled Longitudinal and Transverse Waves Normal to the Applied Magnetic Field in a Three-Fluid Medium," R. W. McClendon and D. L. Murphree, Proceedings of the Tenth International Conference on Phenomena in Ionized Gases, Oxford, England, September 1971, p. 328. Also, Research Report AASE 71-37, Department of Aerophysics and Aerospace Engineering, Mississippi State University, August 1971.

"Expansion and Numerical Solution of the General Dispersion Relation for Small Amplitude Perturbations in a Three-Fluid Plasma, R. L. Brown and D. L. Murphree, Research Report AASE 71-47, Department of Aerophysics and Aerospace Engineering, Mississippi State University, August 1971.

"Analysis of the Mixed Initial-Boundary Value Problem for a Three-Fluid Plasma with a Numerical Example," B. H. Johnson and D. L. Murphree, Research Report AASE 71-52, Department of Aerophysics and Aerospace Engineering, Mississippi State University, August 1971.

"Numerical Solution for Propagation of Longitudinal Waves Along the Geomagnetic Field Using a Three-Fluid Ionosphere Model," T. L. Dahl and D. L. Murphree, IEEE Transactions on Antennas and Propagation, Vol. AP-20, No. 6, p. 807, Nov. 1972.

"Sensitivity of the Numerical Analysis of the Three-Fluid Plasma Mixed Initial-Boundary Value Problem." B. H. Johnson and D. L. Murphree, accepted for publication in Computers and Fluids.

"Theoretical Models and Numerical Studies of Waves in a Three-Fluid Medium," D. L. Murphree, R. W. McClendon, T. L. Dahl, R. L. Brown, and B. H. Johnson, NASA Contractor Report NASA CR-2071, June 1972.

D. The Establishment of an Environmental Sciences Laboratory at The Mississippi Test Facility

As a result of the first six months of effort on this grant it became intuitively obvious that there existed a pressing need for the establishment of an environmental sciences laboratory in the Gulf South area to study the immediate environmental problems confronting this area of the country. It also became readily apparent that the NASA Mississippi Test Facility would be an excellent site for such a laboratory because of (1) large virtually undisturbed natural lands and waters, (2) controlled access to these areas, (3) proximity to a number of universities and

colleges from which senior scientists may be recruited, and (5) a variety of supporting systems and services including a complete computer facility.

Toward this end, Mississippi State University had as the major objectives of this portion of the investigation (1) to form a multi-disciplinary team of scientists capable of operating in a coordinated scientific program and (2) to derive a sufficient amount of baseline information in regard to the overall ecosystem at MTF to serve as the basis for future research proposals to other governmental agencies.

Additional monies in support of this program have been received on NASA-NGL-25-001-040 and from Mississippi State University research funds.

The success of this program has exceeded expectations and the university now has a vigorous ongoing ecological research program funded by a number of different agencies. The experience gained in the inter-disciplinary approach to research problems has resulted in the evolution of an effective and efficient method of administering interdisciplinary research projects involving personnel from a number of different departments, colleges and other institutions. This managerial experience coupled with the first hand ecological research experience of the investigators involved on the program proved most beneficial in designing and implementing multidisciplinary, multi-institutional research programs at Mississippi State University. Additionally, through the continued support of NASA and other governmental agencies an environmental laboratory has been established by the University at MTF with three full-time employees on site.

Publications

1. Vaishnav, Dinesh Divakarrai. "Studies on Growth Characteristics and Penicillin Production by Penicillium Chrysogenum and Penicillium Notatum", M. S. Thesis, 1973.

2. Thumar, Bhagvanji Gokaldas. "The Use of Spent Penicillin Fermentation Medium for the Production of Alcohol and Yeast Protein", M. S. Thesis, 1973.

3. Phillips, Walter Ellis, Jr. "The Effect of Elevated Temperature on the Aerobic Treatment of a Petroleum Refinery Wastewater", M. S. Thesis, 1972.

4. Gibson, William Leonard. "Microbial Degradation of Parathion", Ph.D., 1972.

5. Heins, David C. "The life history and ecology of the longnose shiner, Notropis longirostris (Hay), in Mississippi", M. S. Thesis, 1972.

6. Clemmer, Glen. "The ecology, food and feeding of the longnose shiner, Notropis longirostris (Hay), in the Jourdan River system, Mississippi", Transactions of the American Fisheries Society, 1972.

7. de la Cruz, Armando A. "Organic Content of Waters and Sediments in Four Aquatic Habitats in Mississippi", The ASB Bulletin, Vol. 19, No. 2, April 1972, p. 64.

8. de la Cruz, Armando A. "Mississippi: An Ecological Inventory", Jour. Miss. Acad. Science, 1972.

9. Clark, Opal Dakin. "Seasonal Plankton Populations of the Jourdan River System, Mississippi", M. S. Thesis, 1972.